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TRANSLATION OF JAPANESE 15826-106W01

## TRANSLATOR'S CERTIFICATE

I, Peter Ellis, do hereby certify that I am fluent in the Japanese and English languages. I prepared the translation into English of a Japanese document referred to as 15826-106W01. It is true and accurate to the best of my ability.

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Peter Ellis

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(72) Name of inventor: Shintaro Yamazaki
Ueda Nippon Radio Co., Ltd.: 2-10-19 Fumire, Ueda City, Nagano Prefecture
(71) Applicant: Ueda Nippon Radio Co., Ltd. 2-10-19 Fumire, Ueda City, Nagano Prefecture

Patent specifications
1. Name of invention: Diving work message control device

2. Scopes of invention claims:
(1) A diving work message control for an air tank pressure and work environment supervision device comprising:
(a) An inert gas or air partial pressure calculation element within the half-time tissue at the maximum water depth of specific sampling time, and
(b) A consecutive update and display element of non-depressurizing limit time at the current water depth by means of current air or inert gas partial pressure at (a) half-time tissue, and
(c) A detecting and diver warning element for transitioning to a depressurized diving state after exceeding (b) the non-depressurizing time,
(d) An element to evaluate air or inert gas partial pressure in each (a) half-time tissue, to calculate and to display depressurizing quitting depth as well as depressurizing quitting time, and
(e) An element to supervise air or inert gas partial pressure at the current water depth and each (a) half-time tissue during depressurizing quitting, and to warn the diver about detected irregularities, and
(f) An element to supervise water depth change speed at the floating or sinking state, and to warn the diver about speed considered to be excessive, and
(g) An element to warn the diver if the air tank pressure is below the specific set pressure, and
(h) An element to record environmental data or air tank pressure at a certain recording interval, and a unit to transmit the diving work records to an external general purpose computer.
(2) The diving work message control device in the patent claim (1) wherein the warning element comprises audible or visible elements to fulfil the multiple warning modes.

3. Detailed specifications of the invention

(Industrial application of this invention)

This invention comprises a portable diving work message control unit to monitor the work environment of the diver and the air tank pressure, to display and warn in various ways, and to record the work environment therein.

(Conventional technology)

In the conventional unit, two functional types of device are applied, that is, the message control for the functions of depressurizing limit time, depressurizing water depth, depressurizing time and others, and the air pressure display function.

In addition, the two functions can be integrated into one device. However, the air tank and message display is linked by means of a high-pressure hose as the structure that transmits high pressure to the message display element to indicate relevant data. However, the data cannot be recorded.

(Objective solutions of this invention)

In the conventional device, during the diving work, the structure of the high-pressure hose can be easily scratched or rubbed by rocks or ship trunks, and the display unit can stick to rocks and others objects resulting in great stress on the parts of hose and air tank. Such scratch or tension strains cause pressure fatigue on the air tank pressure that frequently results in physical cracks or tears. Since the air tank internal pressure is 200 $kg/cm^2$ or above, a crack in the high-pressure hose can be extremely dangerous and life threatening to the underwater diver.

In addition, the warning and display elements are audible and visible. A warning signal can be detected audibly, but warning messages can be checked visually by means of an LCD blink or LED light. Therefore, the LED display contrast can be deteriorated and be difficult to read if the external light source in the water is rather highly bright. In addition, the LCD display in a dark environment, e.g. at night, will require a light source for reading. Therefore, confirmation of warning messages is not be continuous.

Next, measures to counter problems during a dive are generally dependent on a diver's memory, which is relatively unobvious, including possible improper actions [by the diver] as well as inaccurate determinations of the cause of the problem.

(Means to solutions in this invention)

The objective of this invention is to design a portable type message control device to improve diving safety that comprises:

(1) An element to give proper indications to the diver based on previous diving processes, current water depth and current diving time, and to record the work environment data and the air tank pressure data, and

(2) An element to transmit data from the air tank joint to the message display area by means of electric cables, and

(3) An element to generate a compensating warning message in terms of two or more types of output and to transmit the recorded data to an external general use computer with an optical telecommunication wireless system by an optical emitting unit.

The application details of invention will hereby be explained by using figures.

(Application)

Figure 1 is an application of this invention, comprising 1: an air tank joint, 101: an air tank pressure sensor, 3: a message display unit, 2: flexible and rigid structure electric cables to connect the air tank joint (1) with the message display unit (3). Next, it also comprises 301: a water depth measuring pressure sensor, 302: a pressure sensor interface circuit, 303: a water temperature sensor, 304: a water temperature sensor interface circuit, 305: a set switch, 306: an event switch, 307: a foot/meter unit selection strap, 310: a 1-chip microprocessor including 311: an A/D converter, 312: a PROM, 313: a PRAM, 314: a CPU, 315: an input port, 316: a timer counter, 317: an input/output port, 318: an output port. This device also comprises 320: an external data RAM, 330: an LCD display unit, 340: a warning ceramic buzzer, 350: a data output and warning LED. Next, 330 in figure 2 is the LCD display unit with 331 to 339 display messages.

Operation of this device will be controlled by the program in the PROM (312) of the 1-chip microprocessor (310). This is explained in sequence as follows.

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(a) During the standby mode on land, the specific interval driving pulse signal from the timer counter (316) originates the intermitting operation of the other circuit of the 1-chip microprocessor (310), the water depth pressure sensor (301) and the pressure sensor interface circuit (302) to monitor the pressure on the pressure sensor (301) and to read the input data of the set switch (305).

When the water pressure ON signal is detected by the pressure sensor (310), the device will switch automatically from the operation standby mode to the non-depressurizing diving measurement mode. When the water pressure ON signal is not detected by the pressure sensor (301), and the set switch (305) ON signal in the CPU (314) is detected by the input port (315), the diving standby mode will be restored.

(b) During the diving standby mode, the input measurement unit will be determined by the foot/meter selection strap (307) through the input port (315). The following explanation is be based on the meter measurement unit. The (331) of the LCD display unit (330) will be set at 'DEPTH' and 0 meter will be displayed, the temperature sensor (303) and the temperature sensor interface circuit (304) will be activated to display the current temperature at the unit (336). Next, the pressure sensor (101) and the pressure sensor interface circuit (302) will be activated, and the air pressure input in (339) will be displayed as 'AIR' with the measurement unit 'bar' on the A/D converter (311).

If the water pressure ON signal is detected by the pressure sensor (301) in this mode, the device will automatically switch to the non-depressurizing diving measurement mode. When the ON signal of the event switch (306) is detected at the CPU (314) by the input port (315), the previous diving data will be displayed; however, if the ON signal of the set switch (305) is detected, the diving plan will be displayed.

(c) During the display of the previous diving data, the diving data in the external data RAM (320) will be searched. The previous data will be searched after the latest data every time the ON signal of the event switch (306) is detected. Diving start data will be displayed: (331) of the LCD display unit (330) gives 'MAXDEPTH' as the maximum depth, (333) gives 'DATE' as the diving date and month, (335) gives 'DIVE' as diving time, (336) gives water temperature at the maximum depth, and (339) gives 'ENTER' as the diving start time. In this manner, the previous diving history will be understood easily.

(d) In the non-depressurizing diving measurement mode, the data of the year, month, date and time during this mode will be recorded in the external data RAM (320); the maximum water depth during the specific sampling period will be displayed as 'DEPTH' in (331) of the LCD display unit (330) through the A/D converter (311) as well as the pressure sensor interface circuit (302) that has input from the pressure sensor (301).

In accordance with the given water depth, the current absolute pressure, Pa, will be read. This Pa will be calculated in accordance with equation (1) to obtain the partial pressure, P, of air or inert gas in each semi-saturated time:

[illegible] …(1)

where:
Pi: is the air or inert gas partial pressure existing in each half-time tissue.
HT: is the semi-saturated time of each half-time tissue, and
t: is the specific sampling period.

In accordance with the maximum water depth D during the specific sampling period and the air or inert gas partial pressure in each saturated time tissue above, P, equation (2) will be applied to obtain the non-depressurized critical time, $t_{LIM}$, at the current depth:

$$t_{LIM} = \ln\left(1 - \frac{M_0 - P}{(D/10+1) - P}\right) \times \frac{HT}{\ln 0.5} \text{ [min]} \cdots (2)$$

[In the last expression: read as ln 0.5 [minute]]

where,
Mo: is the non-depressurizing limit of air or inert gas partial pressure at each half-time tissue. The $t_{LIM}$ of all half-time tissues will calculated in accordance with equation (2), and the minimum time will be the non-depressurizing limit time as the ON signal of the 'LIMIT' [sic], and (332) of the LCD display unit (330) will display the non-depressurizing limit time. Water temperature from the temperature sensor (303) output will be displayed on (336) of the LCD display unit (330), the air tank pressure from the pressure sensor (101) will be displayed on (339), and the diving time, from the detection of the water pressure ON signal until the current time, will be displayed to (335).

This operation will be repeated on the specific sampling interval to update display data consecutively while water depth, water temperature and air tank pressure are recorded on the external data RAM (320). This record will be continued until the water pressure OFF signal is detected.

(e) If the non-depressurized dividing critical data is exceeded, the device will switch to the depressurizing diving measurement mode. In this mode, the CPU (314) will intermittently activate the ceramic buzzer (340) by the output port (318), and it will also notify the diver that the non-depressurizing limit is exceeded by blinking the date output and warning the LED unit (350) at a slow frequency.

In general, it is known that the partial pressure, P, of air or inert gas in each half-time tissue, the safe floating water depth, Dc, and the safe partial pressure, Mo, have the following relationship.

$$P = M_o + a \times Dc / 10 \qquad \cdots (3)$$

By rearranging equation (3), the following expression is obtained:

$$Dc = \frac{P - M_o}{a} \times 10 \qquad \cdots (4)$$

where, a is the constant at each half-time tissue. Equation (4) will be used to calculate all half-time tissues of the depressurizing diving mode, where the maximum depth will be the safe floating depth.

By normalizing the safe floating depth to 3 meters, the optimum depressurizing quitting depth will be obtained. Normalization conditions will include the normalized depressurized depth that is greater than the safe floating depth before normalization.

To obtain the depressurizing quitting time at Ds, the optimum depressurizing quitting depth, it is necessary to know the depressurizing level of partial air or inert gas pressure in the half-time tissue. From equation (3), the partial pressure of the air or inert gas, $P_D$, to float at the depressurizing quitting depth pf Ds-3 (meter) will be

$$P_D = M_o + (a \times (Ds - 3) / 10) \qquad \cdots (5)$$

This will be obtained applying the equation.

By using the following equation (6), the depressurizing quitting time, t, at the optimum depressurizing depth, Ds, will be obtained from the calculated $P_D$ and the current partial pressure P of the air or the inert gas.

$$t_1 = \ln\left(1 - \frac{P_b - P}{(D/10+1) - P}\right) \times \frac{HT}{\ln 0.5} \ [分] \cdots (6)$$

[In the last expression: read as ln 0.5 [minute]]

Equation (6) will be used to calculate all half-time tissue for the depressurizing requirement where the maximum depressurizing quitting time, ts, is the required depressurizing time. Therefore, the calculated optimum depressurizing quitting depth and depressurizing quitting time will be displayed on (333) of the LCD display unit (330) as 'DEC' and Ps (meter) to notify the diver, respectively.

These calculations will be consecutively repeated and updated based on the specific sampling interval during the dive in the depressurizing mode.

(f) During depressurizing quitting, the current depth and the safe floating depth will be compared. In case the diver has floated to a depth less than the safe floating depth, the sound of the ceramic buzzer will be activated continuously, and data output and warning LED unit will blink rapidly while the element (333) of the LCD display unit (330) will blink to notify the diver about the irregular depressurizing quitting state.

In addition, in case the floating speed is slow and the partial air or inert gas pressure in the half-time tissue is less than Mo, and depressurizing is unnecessary, and if the depressurizing quitting is finished, the messages on the LCD display unit (330) will be recovered to the non-depressurizing diving measurement mode, and each warning message will be released, and the (d) non-depressurized diving measurement will be processed.

(g) During the dive, floating and sinking will be monitored. If the sinking speed is 22.5 meters/minute or above, and the floating speed of 10 meter/minute is checked, the ceramic buzzer (340) sound will be activated continuously, the data display and warning LED will blink rapidly, and the 'SLOWLY' in (334) of the LCD display unit (330) will also blink to notify the diver that the floating or sinking speed is too rapid, so he can reduce such speed.

If the input air tank pressure (3) through the pressure sensor (101), the electric cables (2), the pressure sensor interface circuit (302) and the A/D converter (311) is within 50 kg/cm$^2$ during the dive, the CPU (314) will command the ceramic buzzer (340) to sound intermittently through the output port (318), and will command the air tank pressure message on the data output and warning LED unit (350) and (339) of the LCD display unit (330) to blink to notify the diver about lower residual pressure in the air tank.

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Visual warning displays by means of a blinking LCD and LED will be very effective in all probable environmental conditions.

That is, the LED warning will be effective in dark waters where the contrast of the LED will be deteriorated, while the contrast of the blinking LCD will increase with external light in bright waters. Therefore, both warnings will compensate one another and be adequate under changing environmental conditions.

(h) If the water pressure OFF signal is detected by the pressure sensor (301), the device will be at rest mode on the water surface.

On the water surface, partial pressure of air or inert gas at the half-time tissue will be lower. This diminishing partial pressure will give partial air or inert gas pressure using equation (1) by applying the specific sampling interval. When the air tank pressure is no longer read by the pressure sensor (101), the element (339) of the LCD display unit (330) will show the current time as 'REAL' and (335) will show 'INTR' to display the water surface rest time after the floating time.

Furthermore, if the diver will board an airplane after diving, special attention is required since the airplane air pressure is low. Since the air pressure in an airplane may be as low as 0.8 (ATM), if the safely retained partial pressure of each half-time tissue is $P_F$, the time before boarding an airplane, $t_F$, will be obtained from equation (7) as follows:

$$t_F = \ln\left(1 - \frac{P_F - P}{0.8 - P}\right) \times \frac{HT}{\ln 0.5} \text{ [分]} \quad \cdots (7)$$

[In the last expression: read as ln 0.5 [minute]]

where, P is the air or inert gas pressure at the current half-time tissue, and HT is the semi-saturated time.

The calculated time before boarding an airplane, $t_F$, will be displayed as 'FLYING' on (333) of the LCD display unit. This calculation will be repeated, and the display updated, at specific sampling period until the half-time tissue of the air or inert gas partial pressure becomes 1 ATM. When the partial air or inert gas pressure at the half-time tissue becomes constant at 1 ATM, the device will automatically switch to (a) the standby mode. If the water pressure ON signal is detected by the pressure sensor (301) during the rest mode on the water surface, the device will automatically switch to (b), the non-depressurizing diving measurement mode. In addition, if the event switch (306) ON signal is detected, the device will switch to (c), the previous diving data display mode, but if the set switch (305) ON signal is read, the device will automatically switch to the diving plan display mode.

(i) When the device is in the diving plan display mdoe, the non-depressurizing limit time will be calculated at the planned depth in accordance with the partial air or inert gas pressure in the current half-time tissue.

If the scheduled depth is Dp, the non-depressurizing limit time at depth Dp (meter) will be calculated applying equation (8):

$$t_P = \ln\left(1 - \frac{M_0 - P}{(D_P/10 + 1) - P}\right) \times \frac{HT}{\ln 0.5}\ [\text{分}] \cdots (8)$$

[In the last expression: read as ln 0.5 [minute]]

The tp will be calculated to each half-time tissue. The minimum time will be the non-depressurizing limit time; (331) of the LCD display unit (330) will display Dp (meter) as 'DEPTH'; the element (332) will display 'LIMIT' as ON signal, the element (333) will display the non-depressurizing limit time, and the element (338) displays 'PLAN' as the ON signal.

The initial Dp will be 9.0 (meter). Each time the set switch is depressed, a +3.0 (meter) increment will be applied and the equation (8) will be repeatedly calculated and the results displayed.

Since this function enables the diver to know the non-depressurizing limit time at the planned depth at current time on land, the diving plan will be easily designed.

(j) If the diver simultaneously presses the set switch (305) and the event switch (306) ON at the water surface, the data in the external data RAM (320) will be transmitted as the output of the data output and warning LED unit (350) through the output port (318).

The format of the output data will be asynchronous start bit, 1-bit, stop bit, and 2-bit.

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The Output data will be the diving year, month and day, the diving start time, the floating time, and the rest time at water surface from the previous floating time to the diving start time. Next, the data will be water depth, water temperature and air pressure messages of the air tank at the specific sampling interval.

The optical signal data can be converted into electrical signals and transferred to the general use personal computer by means of the optical receptor and a simple RS-232C signal conversion circuit.

(k) The internal power supply voltage will always be monitored with the A/D converter (311). If the dry cell voltage is low, the diver will be notified to replace it with a new dry cell by means of 'LOW BATT' ON signal at (337) of the LCD display unit (330).

Furthermore, the timer counter (316) will function as the clock and program control timing. PRAM (313) will be the data processing area during the programming control, and the input/output port (317) is applied to transfer data between the external data RAM (320) and the LCD display unit (330).

In this application, the partial air or inert gas pressure is calculated in terms of air pressure. However, it can also be evaluated as the absolute water depth by setting the absolute depth of the water surface as 10 meters.

In addition, the ceramic buzzer (340) can be designed to stimulate the skin of the diver by installing it to the back side of the data display unit (3) that will be wrapped to the hand wrist of the diver.

(Effects of invention)

By adopting the structure as well as the control software described above, the device will require no high pressure hose that will both avoid conventional harm of cracking or failure of the high pressure hose and will respond rapidly to changes in the diving environment. In addition, the multiple compensating warning functions will improve the safety of the diver significantly. Next, it will also be helpful to identify the causes of accidents by reading the environmental data and the air tank pressure data that are recorded during an accident.

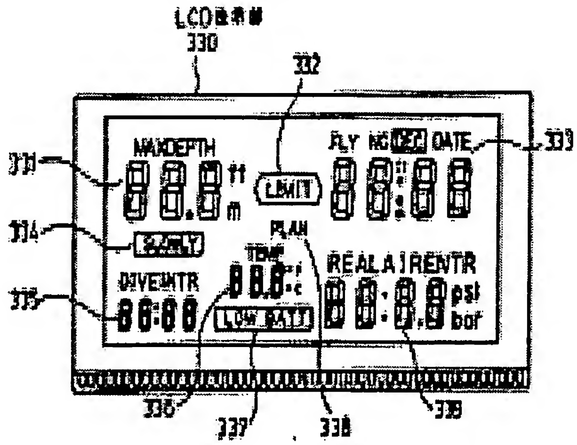
4. Brief explanation on figures.

Figure 1 shows arrangement in application example of this invention, and figure 2 outlines of display unit in this application.

1 ... Air tank joint, 101 ... Pressure sensor,
2 ... Electric cables, 3 ... Message display unit,
301 ... Pressure sensor, 302 ... Pressure sensor interface circuit,
303 ... Temperature sensor, 304 ... Temperature sensor interface circuit,
305 ... Set switch, 306 ... Event switch,
307 ... Foot/meter selection strap, 310 ... 1-chip microprocessor,
311 ... A/D converter, 312 ... PROM,
313 ... PRAM, 314 ... CPU,
315 ... Input port, 316 ... Timer counter,
317 ... Input/output port, 318 ... Output port,
320 ... External data RAM, 330 ... LCD display unit,
340 ... Ceramic buzzer, 350 ... Data output and warning LED unit.

Patent applicant: Ueda Nippon Radio Co., Ltd.

Figure 2




[In 330, read as 'LCD display unit']

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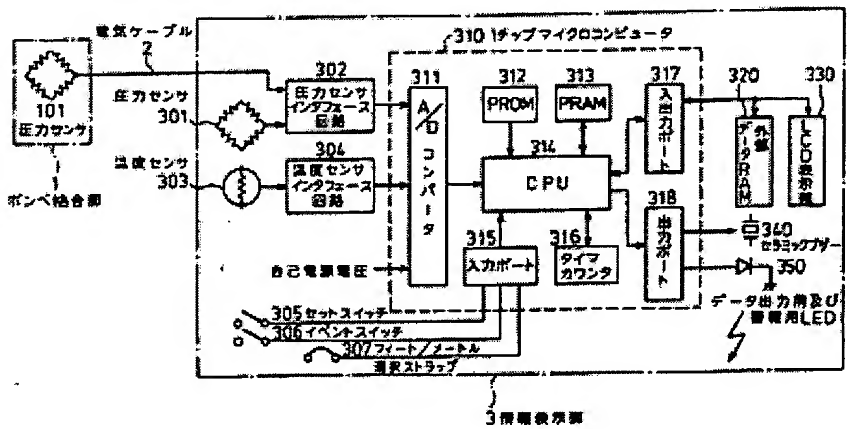
Figure 1




[Text translated by number:]
1: Air tank joint, 101: Pressure sensor, 2: Electric cables, 301: Pressure sensor, 303: Temperature sensor, 302: Pressure sensor interface circuit, 304: Temperature sensor interface circuit, [below 304: Internal power supply voltage], 305: Set switch, 306: Event switch, 307: Foot/meter selection strap, 310: 1-chip microprocessor, 311: A/D converter, 317: Input/output port, 315: Input port, 316: Timer counter, 318: Output port, 320: External data RAM, 330: LCD display unit, 340: Ceramic buzzer, 350: Data output and warning LED unit.